An extract from a Clinical Lecture delivered before the Class of the Medical Department of the University of Wooster, containing some remarks on a new method of treating Hemorrhage from arteries divided during operation.

BY

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OF

CLEVELAND, OHIO.

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An extract from a Clinical Lecture delivered before the Class of the Medical Department of the University of Wooster, containing some remarks on a new method of treating Hemorrhage from arteries divided during surgical operations.

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GENTLEMEN: — The case which I now propose to present to you is, clinically, one of considerable interest, not so much from any difficulties, which may arise in determining its actual pathological character, as on account of the importance of the measure, which, by a due and careful appreciation of all the features of the case, therapeutically appears to be indicated And yet I ask you to-day to be satisfied, with reference to diagnosis and therapeutics, with a simple statement of the results of my own examination and with my opinion as to the propriety of treatment.

The patient, whom you will see, — a woman from the lower walks of life, forty-six years of age, has been for a number of years a sufferer from all manner of cutaneous difficulties, appearing in nearly all the typical

forms known in dermatology; the results of the more serious ones, in the form of smaller or larger irregular cicatricial tissue, are still visible on different parts of the body.

These cutaneous affections were associated with ulcerative processes about the fauces and larynx, and were followed by inflammatory changes of the periosteum and the bones in several parts of the skeleton, on the clavicle, some of the bones of the cranium, the ribs and the bones of both legs. These inflammatory affections have at different times, led in several instances to the development of caries and limited necrosis, to which the scars in the localities mentioned bear emphatic testimony. The history of the case dates back more than twenty years. The various symptoms enumerated, commencing when the patient was about twenty-five years of age, reveal, even without the assistance of the free confession as to the causation, very readily the true nature of her malady. She has been the victim of the ravages of constitutional syphilis for more than twenty years.

Up to within three years ago, the various manifestations of this disease had been promptly controlled by treatment, so that at times she enjoyed a fair degree of health But from that time onward to the present she gradually became cachectic; and instead of transient evidences of the peculiar dyscrasia here and there over her body, she has been suffering for more than two years with caries of some of the tarsal bones of the right foot, also with indolent ulcers of the right leg, laying bare the tibia and upper portion of the fibula at different points and extending some two inches above the knee joint. The whole right leg is covered with

cicatricial tissue hugging tightly the more prominent parts of the bones, the tissue being contracted about the knee joint, materially interfering with its motion.

For the last two years she has been under the skilful treatment of my colleague and friend, Dr. D. B. Smith; but in spite of the very best efforts on his part, her constitutional and local difficulties have slowly but surely, increased, and at the present time it has become very apparent, that some more active measure must be instituted to stay its progress and the impending fatal termination.

The patient is suffering from that peculiar cachexia, which is often superinduced by the continued influence of syphilitic virus, the heroic administration of the various powerful remedies used for the destruction and elimination of the latter; and probably also by a mode of life little calculated to maintain the integrity of the various vital processes, so necessary for the counteraction of the pathognomonic inroads of the virus upon the nutritive force of the body. She is also, suffering from infection with some of the decomposed products of inflammation and mal-nutrition of her organism.

For the last two years, few new manifestations of the disease have made their appearance on other parts of the body. But those of the right lower extremity have, as has been stated before, steadily increased and by the continued introdution of pyrogenous subtances, undoubtedly led to the rapid wasting away of her body, characteristic of her present condition.

In view of these facts it has been decided in consultation, to remove this source of the deterioration of her blood by amputation of her limb, in the hope that, after this is accomplished, proper and judicious treat-

ment may ultimately overcome the changes wrought in her nutritive forces, by her constitutional disease, and return her to a comparatively fair degree of health.

I propose presently to perform that operation through the middle of the thigh by the method known as the double circular incision ; by this the skin is first circularly divided, and after its retraction, the muscular structures down to the bone.

This operation in its mechanical execution is simple and easy, hardly worthy of a clinical discussion ; and yet it is one, which from its bearings upon the immediate or more remote effects on the organism of the patient, is dreaded by almost every thinking and conscientious surgeon.

Among these effects, which can seriously influence the patient during the performance of the operation and afterwards, during the process of repair requisite to bring about the accomplishment of the object of the operative interference, we will mention as the most important and most dreaded : the shock to the system at large ; the loss of blood, and furthermore the development of the pyrogenous and phlogogenous substances in the wound, entailing excessive septic infection and local inflammation of a destructive character.

To prevent and do away with these effects is the duty of every surgeon who would be true to the trust confided to him, when called upon to perform such an operation. And I am happy to be able to state to you, that the profession is fully aware of the vast importance of this subject and is diligently and rationally striving to devise means which will lessen, not only the dangers of the injury which we necessarily inflict during amputation of a limb, but also those, which surround nearly all

operative proceedings and manifold injuries, coming under the eye of the surgeon. The labors of the indefatigable Lister, with those of his colaborers in the field of the antiseptic method of treating wounds, and the glorious invention of Esmarch, the great Surgeon of Kiel, are proofs of the truth of this assertion.

Now, Gentlemen, I shall have frequent opportunity during the present session, to speak to you of these various influences, local and constitutional, immediate and remote, of amputations as well as operations in general upon the organism. So with your permission, I shall detain you to-day, before proceeding to perform the operation in question, in order to discuss the means employed to guard against the injury, that may be done by one of the most immediate effects of the majority of surgical acts. I refer to hemorrhage or bleeding from divided vessels.

I have selected this subject for discussion, partly for the purpose of making those of the gentlemen, who as yet are strangers to the various phases of the operating room, familiar with one of the most important acts of a surgeon; partly, to explain to those who have witnessed similar operations, the differences in the modus operandi, which I shall employ and which they will readily detect, for I propose to make use, in this operation, of the so-called "bloodless method" of operating, as suggested by Esmarch; and also of a plan, which I have devised for the permanent closure of divided arteries.

This subject of hemorrhage, surgical hemorrhage, is one of vast importance. It should receive on your part its full share of study and careful consideration at the very beginning of the lectures on operative surgery. Not until you fully understand it, so that you can feel,

that under all circumstances you can master it, will you be able to undertake even the slightest surgical operation, with satisfaction to yourself and safety to your patient. The skill. dexterity, and coolness, which mark the experienced surgeon during the performance of the most difficult operation, spring from the consciousness of being, let come what will, master of any hemorrhage, which may occur.

The division of any of the structures of the body necessitated by surgical therapeutics. is naturally always accompanied with more or less bleeding. Thus at nearly every step of an operation, hemorrhage presents itself to the operator, either in the form of capillary, parenchymatous, venous, or arterial hemorrhage. Knowing that there exists a marked difference in the size of the various vessels of the body, in the quantity of blood they carry, in the structure of their coats, in the influence of the 'vis a tergo' upon the column of the blood contained within them, in the various vascular territories and, also, in the tissue surrounding them, it is very apparent, that these four varieties of hemorrhage differ in practical significance. In fact, you will readily become convinced, that under ordinary circumstances only arterial hemorrhage is the special object of the surgeon's care and anxiety. There are conditions however — sometimes hereditary—which may lead to an excessive, often dangerous loss of blood from the division of even the finest capillaries, where by changes in the chemical and histological composition of the blood, by modification of the structure of the vessel, and probably of nerve power of the vaso-motor nerves, a spontaneous arrest of the flow of blood is impossible. These conditions at times exist constitutionally, and are described

under the term of Haemophilia. Then again the surrounding tissue may prevent the change in the divided capillaries which is necesssary for their spontaneous closure, and with which I shall presently attempt to make you familiar. Thus in tense and unyielding tissue, in the parenchyma of some of the organs of the body, a division even of fine and delicate vessels is followed by tolerably profuse bleeding.

Ordinarily, capillary and parenchymatous, as well as venous bleeding, are spontaneouly arrested without the least assistance on the part of the surgeon. And you will even observe arteries of considerable size cease bleeding, without the application of any of the means known for the artificial arrest of hemorrhage. Many of the gentlemen will have wondered in coming from the dissecting table, where they followed with the scalpel, the many anastomosis of the well injected principal arteries of an extremity, why in the operating room after all, only a few of these vessels require the attention of the operator. At this period in the investigation of this subject, the question will naturally be offered; How does this spontaneous arrest of hemorrhage take place in the divided vessels? How does nature succeed in closing temporarily or permanently the opening in a divided vessel?

In order to appreciate the therapeutical value of all the different means which we propose for the arrest of hemorrhage from any of the vessels, it will be necessary to understand, as far as we can, the process nature makes use of for that purpose. I am sorry to be compelled to acknowledge, that I am unable to present to you undisputed facts in the premises, for it must be admitted by every one, familiar with the results of the investigation

of all those who have contributed to the elucidation of this interesting subject, that its discussion cannot be considered definitively and permanently closed. Yet there is sufficient knoweldge to explain approximately this process of nature, and with it the correctness of at least some of our therapeutic agents. We shall have to premise a short sketch of the histology of the blood-vessels, in order to understand what is generally conceded to be the sum and substance of this matter at the present day.

You will not expect me to enter into details, for they would lead me far beyond the limits of an occasion like the one which has brought us together here to-day. For a more minute study of this subject I shall have to refer you to the elaborate article "On The Bloodvessels" in Stricker's Handbook of Histology, by C. J. Eberth; and also, to the chapters "On The Tissues of the Body" in the carefully written work entitled "The Histology and Histochemistry of Man" of Prof. Frey of Zurich.

The vessels, which carry blood in every direction over the body, viz: the arteries, veins and capillaries, are membraneous tubes of variable size and form, possessed of an extraordinary amount of elasticity and contractility. These qualities vary greatly with the size and the arrangement, quantity and quality, of the tissue of which they are composed. Thus in the minute capillaries, composed simply of spindle-shaped or polygonal cells, fitted together so as to form the finest of cellular membrane, we observe, quite, active, vital contractility, which in the larger ones, and in the arteries and veins, by the interposition of elastic connective and muscular tissue in their walls obtain a degree of elastic-

ity and contractility which intimately corresponds with the necessities of their function in different regions of the body.

The membranes of which these vascular tubes are constructed, vary in thickness and number with the different vessels. Thus, as we have already indicated, the finest capillaries, of a diameter of not more than 0,0045—0,0068 mm. are composed of a very delicate membrane, which is perfectly transparent and apparently structureless until treated with a solution of nitrate of silver, when its cellular character is proved. In larger capillaries, which are situated near the arteries or veins, this cellular membrane is strengthened by the superaddition of another delicate homogeneous membrane; and in still larger ones, by an addditional covering of a layer of delicate connective tissue. As the capillaries gradually merge into the ultimate termination of the arteries and veins, the thickness of their walls is further increased by the fact, that between the two internal membranes and the layer of connective tissue, a thin layer of contractile fibrillary cells and distinct nuclei (arranged circularly around the longitudinal axis of the vessels) is interposed. All these layers observed in the larger capillaries gradually grow thicker, and be-more important, until, in the arteries and veins, we recognize three distinct coats of the vessel, viz. an external one or *tunica adventitia*, composed of fibrous and elastic tissue with its fibrillae and filaments surrounding it spirally, obliquely and netlike; next, a middle coat, or *tunica media,* this coat forming the main thickness of the arterial vessel. It has a yellowish color, consists mainly of muscular and elastic tissue, and surrounds the vessels for the most part circularly. The third

is the internal coat, or *tunica interna*, formed by the original cellular membrane, as observed in the most primitive form of capillaries. It consists of a homogeneous elastic basement membrane and of layers of elastic tissue, forming netted and fenestrated meshes pursuing a longitudinal direction. To the external coat the vessels mainly owe their tenacity; to the middle and internal, their elasticity and contractility. Veins and arteries differ greatly as to the relative amount of tissue in these three tunics, and in the arrangement of fibrous and elastic as well as muscular stuctures. It is this difference which furnishes the peculiar characteristic features of each set of vessels. Thus in the arteries of medium caliber, the middle tunic is the thickest and gives the vessel its peculiar cylindrical form, which enables us readily to distinguish an artery from a vein; whereas in veins the external coat is the thickest, the thickness increasing with the caliber of the vessel. In arteries however, the middle coat, composed to a great extent of unstriated muscular tissue, varies inversely as the size of the vessel. Besides these three tunics proper which enter into the structure of vessels, the latter are loosely surrounded by a network of connective tissue. This helps to fix the tubes in the territories through which they pass, and in the largest arteries and veins it takes the character of an additional coat, surrounding them sheath-like, being unquestionably destined to maintain them in proper relation to the surrounding tissues. The three coats are nourished by the so-called vaso-vasorum vessels, which ramify mainly upon the middle and external coats; and their innervation is accomplished by the vaso-motor filaments of the sympathetic and spinal nerves.

The blood, Gentlemen, which courses in these vessels, is a most complicated fluid, and the centre of all vegetative vital processes. According to calculations of Welker, it makes up in the new-born child about $\frac{1}{19}$, and in the adult $\frac{1}{13}$ of the entire weight of the body. Its various histological and chemical elements are maintained in proper reciprocal relations so long as it is propelled through the different channels of the vascular system with normal velocity and according to the proper dynamic laws. But whenever those relations vary materially, or cease altogether, as when the blood escapes from its physiological abode, the fluid condition is lost, and the blood coagulates.

The coagulation of the blood is due to the solidification of its fluid intercellular substance, brought about by the formation of a body called fibrin. With our incomplete knowledge of the protein bodies of the animal organism, the character of fibrin can not be accurately stated. Chemically, it varies from the albumen of the blood, the chyle, and lymph, merely by a slightly higher degree of oxidation; yet, in its coagulation it presents entirely different physical characters from those of coagulated albumen. It has been supposed that fibrin, as a destinct protein body, is held in solution in the blood-plasma, and that its physical features are evolved only when it leaves the body or when exposed to chemical and physical influences different from those which prevail during physiological position and motion. Experiment and observation however, favor the views expressed by A. Schmidt. He maintains, that blood and all fluids which yield fibrine, contain a fibrinogenous and a fibrinoplastic substance. We call the former also "meta-globulin" and the latter "para-globulin", and

believe the former to be contained in the blood-plasma, in nearly all serous fluids and fluids permeating muscular and connective tissue. The latter is bound to the cellular element of the blood and the structures, which contain the fibrinogenous substance. The fibrinoplastic power is set in activity whenever the fibrinogenous substances become subject to other than physiological influences. Now, while our understanding of the details concerning the coagulation of the blood is unquestionably rather limited, the clinical fact is authentic, that coagulation takes place, with somewhat variable rapidity, soon after the blood has left its accustomed channels and the living body, accidentally or otherwise; that in fact already on its way out, it congeals under ordinary circumstances, and forms props of coagula that reach often to a considerable extent into the vessel from which the blood was derived. These ordinary circumstances exist, whenever the opening into the vascular territory is such that the blood-pressure is materially diminished in the province which furnishes the blood, so that the fibrinoplastic influence of the cellular elements of the blood can be fully exercised, and that the opening can retract within the surrounding muscular or connective tissue, pregnant with this same fibrinoplastic material. Experiment and clinical observation have shown, that whenever the blood is expelled under almost normal blood-pressure, as in longitudinal wounds, or by division of large arterial trunks, the coagulation of the blood does not begin in the vessel. This would go to demonstrate, that the diminished pressure of the blood at the instant of its escape from a vessel, is the brief moment which calls out its fibrinoplastic agents. Besides these general cau-

ses leading to the development of thrombus in an open bloodvessel, we can detect other conditions which will facilitate it and assist in the spontaneous arrest of hemorrhage. Thus the coagulability of the blood greatly increases with the increase in the amount of the loss of blood. Bruecke has demonstrated, that the last four drops of blood coming from an animal dying from hemorrhage, almost instantaneously coagulate, although under these circumstances the blood is excessively poor in fibrine.

We must recognize, then, in the physiological changes wrought by injury of a vessel as well as in those of the surrounding textures, a potent element for or against the formation of clot. The various tissues, divided accidentally or otherwise, and the vessels, when severed, contract, both, by their own vital character, and by nerve influence; a mechanical act is thus brought to bear upon the blood. In the first place a certain amount of pressure will be exercised by the contracted tissue upon the vessels; and next, the contracted vessels will furnish an impediment to the exit of blood, and assist in its coagulation. There can be no doubt as to the fact, that to this peculiar power of coagulation of the blood, to the formation of a clot of blood or thrombus under proper conditions, is due the spontaneous arrest of hemorrhage from openings in the vascular tissue of the body. But in order that that formation should be possible, the opening evidently must be of a nature such as to cause the fibrinoplastic element of the blood and surrounding tissue to exert its power.

During the performance of a surgical operation, this is nearly always the case. Quite a number of bloodvessels, large and small, are opened at once, and

owing to the collective escape of blood, the lateral blood-pressure is greatly diminished. Then, the tissue, by the application of the stimulant of the operation and by their own vital contractility, contract, press upon the sides of the vessels, and impede the flow of blood. Finally, the vessels themselves retract and contract, so as not only to furnish an obstacle to the flow of blood, but also to enable it at once to come in contact with the fibrinoplastic substance contained in the cellular elements of the surrounding tissue. If you will recollect the ingenious arrangement of the different layers of the coats of the vessels and also their histological character, you can appreciate the quantity of retraction and contraction, and of impediment, which will be produced. You will then readily understand, why it is that in many operations, entailing quite extensive division of structures and vessels of different size, unaided nature is generally incompetent to prevent undue loss of blood. And you will be able to explain also, why in cutting very large vessels, we are compelled to interfere promptly, to prevent the disastrous effects which would follow uncontrolled hemorrhage.—In order, Gentlemen, to make this subject still clearer to you, let us for a moment consider the nature of the changes, which are observed to result from the inherent contractility of the more important vessels when divided. The typical form of these changes we can study in an artery of small size, which, when severed, presents the characteristic cylindrical form. The same changes, variable only in degree can unquestionably be demonstrated in almost all the different vessels. The middle coat of a small sized artery is the thickest of the three coats, and possesses beside the elastic fibres, arranged in circular and fene-

strated network, considerable muscular tissue which will contract, when stimulated or deprived of the normal tension maintained by the presence of the blood. This contraction will be beyond the limit of the vital contraction of the internal tunic, more especially of its cellular lining, and must cause a folding up of this layer of the vessels. In fact, we find that this takes place to a considerable extent. The entire intima is fluted longitudinally as distinctly as the ruffles of a lady's garment and this must offer considerable impediment to any flow of blood from the open mouth of the vessel. It is very probable, that this pleating of the intima is a very active stimulant to the formation of the clot. The middle coat in the larger arteries looses a great deal of its muscular elements, and the chances of spontaneous arrest of bleeding from such vessels are materially lessened. It is to my mind a proper question, whether this is due to the absence of the folding of the intima, or merely to the fact, that the vis a tergo is increased so that a clot cannot resist it. If a clot can be formed, it will be proportionate to the dimensions of the vessel; hence in a larger vessel the clot is as competent to resist the impetus of the blood, as a smaller clot in a narrower vessel.

The external coat of the artery, composed mainly of longitudinal and oblique fibres, retracts the vessel after division, so as frequently to conceal it within the surrounding tissues. The overlapping of these tissues also impedes the exit of the blood. From what has been said of all these physical changes in the injured vessel, it would seem rational to suppose that they are linked with the vital changes in the blood, and that thus the object of the spontaneous arrest of hemorrhage is attained.

The next question is of great interest and importance, on account of its bearing upon the various methods of treatment required when nature fails. It is this: "In what manner is the permanent closure of the vessel effected?" In former years, it was thought that inflammation furnished plastic material, which organized, and filled up and obliterated the opening. Consequently it was the surgeon's mission, whenever it became necessary to employ artificial means for the temporary arrest of bleeding, to apply them in a manner such as would guarantee the supervention of inflammation. The surgeon was instructed to apply his ligature in a manner such as to break the brittle internal and middle coats, in the expectation that they would roll up and come together in the line of their fracture, and readily unite by adhesive inflammation. It was believed that without this the process of permanent closure could not be completed, and that secondary hemorrhage would then naturally follow.

Virchow, Billroth and C. O. Weber, however, have endeavored to establish the fact, that the final closure was due not to inflammatory action, but to the organization of a clot. Of late, several contradictory statements have been published. In 1869, Dr. Tschausoff published an elaborate article in The Archive of Clinical Surgery of Langenbeck "*On the thrombus following Ligature*," in which he tries to prove by a series of carefully conducted experiments, that the thrombus itself does not organize, but that it is only a temporary formation; and that the obliteration emanated from the walls of the vessel. Now let us look into this matter more closely. . . . . .

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Whatever may be the exact process which definitely repairs the damage done to the vessel, it is surely conceded by every one, that it can be completed independently of inflammatory action, and that the supervention of the latter may prove an obstacle to the completion of the reparative process.

It would therefore be very desirable that all of the measures which we may be called upon to employ, be so used as not to excite inflammatory action.

The method which proves the least irritating and injurious will be the one most worthy of our confidence.

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Now, if you critically consider these various methods of treatment for the arrest of arterial hemorrhage, you will readily admit, that every one adds to the injury already done to the vessel by division. Their action is entirely mechanical, having no regard to the process nature employs for the spontaneous arrest of the flow of blood. The ligature constricts the end of the vessel, so as to entail the death of the little piece on its distal side. It usually breaks the internal and middle coat, and must naturally be a source of irritation. The views which we entertain with respect to the possibility of development of phlogogenous substances in wounds, lead us to suppose that the ligature can readily become the nidus of that destructive agent. The string of silk and linen ordinarily used for ligature, will, seton-like, imbibe fluids of the wound ; decomposition of these, with development of minute animal and vegetable organisms, will necessarily result, and a source of local and general infection be produced. Metallic ligatures may not be open to this objection ; but they constrict, and lead also to the death of a small portion of the vessel, sufficient for disintegration and formation of septic matter.

Torsion twists and tears the various coats of the vessel; this must lead to modifications of nutrition, inflammation and possibly also to the destruction of a certain amount of tissue. The same results must follow the use of the method of treating the artery by *refoulement*, *machures* or *applatissement*. The more modern improvements in these latter methods, as suggested by Drs. Spier and Stearns, are not exempt from these objections. Perplication, the method of Dr. Stilling, is very difficult of execution, and, for safety, too uncertain in its action. With acupressure, the end of the vessel is not injured, yet it brings additional injury by the passage of needles, and does not command the confidence of the operator as regards safety.

The *aculausur* of Schmitz may be objected to for the same reasons.

It is unnecessary to detain you much longer with a minute discussion of the various disadvantages of these different methods of treatment known to our art. Diefenbach in his operative surgery recounted, over thirty years ago, many of these objections, and expressed the opinion that the profession was alive to the importance of the subject, and striving to perfect this part of surgical labor. He stated, that some of the best men had made efforts to suggest improvements, but that the ligature, with all acknowledged deficiencies, had still maintained itself from the days of Ambroise Paré down to the present time. If we study the recent books and current periodical literature on the practice of surgery, we become convinced that the sentiment of Diefenbach still holds true, that the profession still feels the necessity of continued effort to devise means less wrought with danger. I have had the opportunity of giving this subject considerable thought, and am now certain that we cannot hope for a realization of the object of these efforts, so long as any proceeding suggested entails additional injury and disregards, the teachings of nature.

We should have a process of treating the divided vessel, which would simply assist nature, not supplant her by mechanically acting principles. The failure of nature to spontaneously arrest hemorrhage in larger sized arteries is unquestion-

ably due to the fact, that they do not possess, for cogent physical reasons, sufficient muscular and circularly arranged fibres to bring about the contraction and diminution of the short axis of the vessel, and to effect longitudinal pleating which we believe important both, for the evolution of the fibrinoplastic agency and the security of the clot when formed. It does not seem probable to me that, other things being equal, the greater force of the blood, on account of the larger size of its column, should be the only reason why the spontaneous arrest cannot take place in a larger vessel.

We know that the muscular tissue of the middle coat, the chief contractile material, is not commensurate with the size of the vessel, that in fact, as remarked before, it positively diminishes with the size of the vessel. There must be a reason for this; it cannot be accidental. It must find its explanation in the physical necessities of the circulation of the blood in large vessels.

Now if this be correct, and if the want of sufficient contractile force is the cause of the non-arrest of bleeding, can we not rectify matters by simply doubling or trebling the amount of the circularly-acting tissue, by turning the end of the vessel inside out, as we would turn up the cuff of a sleeve? By so doing, we would obtain double or treble the amount of contractile force, and also furnish an equivalent for retraction. I conceived this idea of imitating nature in the arrest of hemorrhage a number of years ago, and often expressed the same to former classes of students and to my private pupils; but the, question naturally arose, whether it was mechanically possible to accomplish the process of turning over such small tubes as arteries.

With a view to the solution of the question, I looked around for some instrument to assist this mechanism. My first thought suggested a delicate, toothed forceps with which to enter the vessel up to the point whence the reflection should be made; then to take hold with it, and with another forceps to grasp the end of the artery so as to enable me to slip the piece intervening between the first and second forceps over the fixed point at the first forceps.

Then again I proposed to use a single or double hook. Finally, in thinking over the various instruments which might be applicable or constructed for that purpose, I hit upon a little instrument invented by M. Lüer of Paris, and called by him *fixateur à gaine*. Experiments on dogs soon taught me, that what appeared at the first glance so very difficult, was quite easy. In fact in trying the instruments which have been mentioned, I was astonished at the ease with which that turning of the end of the vessel could be accomplished. The experiments were performed with the assistance of my friend and former pupil, Dr. D. B. Smith. But another difficulty presented itself which then seemed an unsurmountable obstacle to the realization of the object of our investigation: viz the fact, that after the reflection was made, the alternating distention and contraction of the vessel soon forced the reflection back to its original position. While, however, the reflection remained *in sito*, the quantity of blood oozing out was very small. We selected the iliac and the aorta abdominalis for these experiments, and found, that in the former it required about ten beats of the pulse before the vessel was streightened out again, while in the latter only about six were required. We also found, that the fixateur à gaine was the instrument, which accomplished the object most promptly without lacerating or injuring the internal coats.

Since making these limited experiments, I have made a number of attempts to test this principle of treatment on the human subject; but on account of the poor construction of the instrument I had to abandon my endeavors in that direction. Of late, however, the enthusiasm that I felt when first working out what I think is an important principle in surgical therapeutics, has revived, especially since with the application of the method of Esmarch, which I have described to you, the possibility is given to make these experiments on the living subject without endangering the life of the patient. That you may understand fully the modus operandi of the method (which I propose to test in the case of amputation presently to be performed), I show you these illustra

tions. If this proceeding of treating arteries succeeds, I propose to give it the name of aërteriversio, and the instrument the name of aërteriverter. My distinguished friend M. Lüer will pardon me that I make so free with an instrument of his invention.

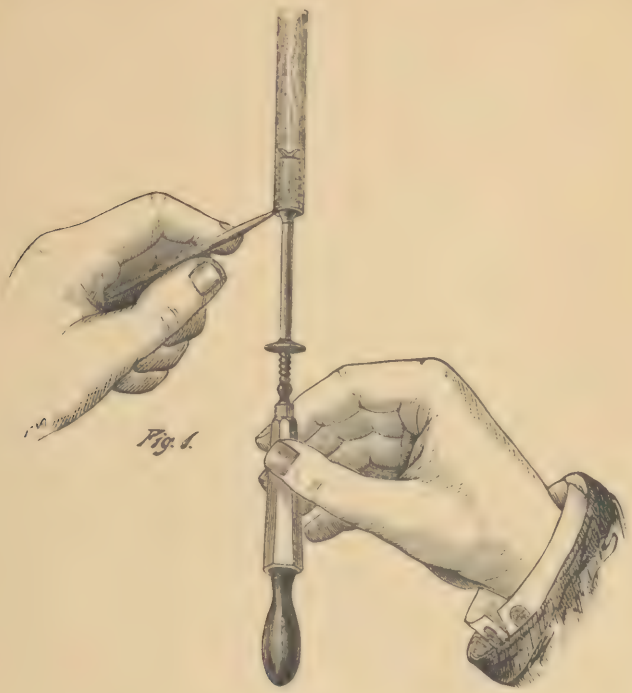

Fig. 1.

Fig. 1 represents the aërteriverter introduced up to the points where the artery is to be turned with the double hooks extending a little beyond the cylinder.

Fig. 2.

Fig. 2 will give you an idea of the condition of the artery at the moment the end is reflected prior to the removal of the instrument. You can imagine that I enter upon this trial with a considerable degree of trepidation, remembering the difficulty previously experienced owing to the fact that the

reflection would not remain in place, and that my aërteriverter has not improved by occasional use. I hope, however, to overcome the first difficulty by making the reflection quite extensive, and, with a view of securing it in place, notch the vessel at the point of reflection, so as to enlarge it there and thus offer an obstacle to its slipping back. If this should not prove sufficient, I propose to introduce immediately behind the point of reflection, a little delicate peg, made of the end of a number 12 English sewing needle, after the manner depicted in Fig. 3.

Fig. 3.

Should the contraction, after the reflection has been accomplished and secured, fail to instantaneously arrest the bleeding, I shall do that which we have to do occasionally in hemorrhage from capillaries and smaller vessels, viz: for a short time apply a digital compression to the end of the artery, while at the same time I shall prevent the blood from exerting its full force in the end of the vessel.

With this I expect to obtain a temporary clot which will answer the purpose. Should we have the good fortune of realizing that the possibility and practicability of this treatment will be demonstrated, there will then be ample room and occasion for further study.

With these hasty remarks we will leave the discussion and proceed to the performance of the operation."

At this juncture the patient was brought in, and, after being placed under the influence of ether, the operation was performed in the manner above indicated, the division of the muscular structures falling in a line a little above the union of the upper third with the middle. The bandage and elastic tourniquet of Esmarch prevented any loss of blood save possibly that of a dozen drops. Two muscular branches were secured by ligature, but the femoral was treated in the manner described. Although the instrument used was poorly made, the little hooks not being placed in a direction such as to enable them readily to be hooked into the walls of the vessel at the point of reflection, yet the act of turning was comparatively easy. After the reflection had been made, the tourniquet was loosened sufficiently to allow the pulsation of the vessel to be seen, when a fine spiral stream of blood escaped from the artery *per saltum*. I then notched the vessel by means of a pair of fine scissors at each end of a transverse diameter. The notch was made through the two walls- the main wall and the reflected-, and, commencing at the point of reflection, extended about two lines in a longitudinal direction.

Owing to the contraction of the circular fibres after division, a wedge-shaped gap was formed at each notch, so that the circumference of the vessel at the edge of reflection was increased. This caused the reflected piece to appear to surround the end of the vessel more closely, in fact, to constrict it. These steps of the experiment were made with the stump almost extended. While in this position an irregular spurt of a small spiral stream of blood was observed, whenever the blood was allowed to be driven into the artery by the full force of the circulation. When, however, the stump was flexed at right angles with the body, no such spurting took place. Fearing that hemorrhage would not entirely cease, and appreciating the debilitated condition of the patient, I felt it necessary to guard more thoroughly against any sudden loss of blood. I therefore introduced, immediately behind the points where the vessel had been notched, two of the little pegs which I described before. They were placed so as to cross each other at right angles. On account of the remarkable retraction of the surrounding muscular tissue, and owing to the fact that it required considerable manipulation to make the

aërteriverter work, the vessel was quite prominent, and not withdrawn into the surrounding tissue. This enabled me and those present to become convinced, that the vessel, after the application of the pegs, was hermetically sealed; for notwithstanding that the full force of the blood was pumping against the end, so as to raise and depress it with every wave, not a vestige of blood escaped. The wound was allowed to remain open, in order to give an opportunity to study the process of repair.

At the end of about half an hour, the patient having been placed in bed and the stump supported by compresses, one of the pegs was removed. For nearly forty-eight hours the vessel moved with every pulsation; yet, on applying the sense of touch, no dilatation could be felt within over an inch from the end of the artery; and I felt justified in supposing that the artery was well closed by clot. Gradually the wound became covered with granulations, which increased until the stump of the vessel was completely removed from view.

The process of repair was tedious, as was to be expected from a constitution like the one we had to deal with. The patient finally recovered, however, and at the present writing enjoys a fair degree of health. I am unable to state what has become of that little peg.

Since the performance of this operation, I have had the opportunity of employing this method in three cases. The first was an amputation immediately below the shoulder joint. The brachial was treated by simple reflection and one peg. The patient had been an intemperate man, and fearing the development of delirium tremens, I thought it best to apply the peg in addition to the reflection, although this alone closed the vessel. The patient died of septicaemia on the twelfth day, and upon making a post mortem examination, I found the entire wound in a gangrenous condition, and yet the artery nicely closed by a thrombus of an inch and a half in length, presenting its characteristic form, and having already entered at several points into firm connection with the tunica intima.

The second case was an amputation of the leg through the middle third, where the anterior and posterior tibials were treated by simple reflection and one peg. The peg, which was

passed through the anterior tibial, was removed within twenty minutes. This patient recovered rapidly, without the slightest untoward occurrence. Three days ago it was my privilege to try this method again on the femoral, after an amputation through the middle third by my friend Professor Holliday, of the Cleveland Medical College. The artery was reflected, one peg inserted, and the bleeding instantly arrested. During all these trials I labored under the embarrassment and difficulties naturally resulting from an insufficient instrument. On account of the poor quality of the hooks, the instrument failed to take hold readily. Repeated attempts had to be made before I succeeded, and it is reasonable to suppose, that in these attempts the various coats, more especially the brittle internal and middle coats, were more or less injured, so that their contractile power, by which the cross section of the vessel could be diminished, was considerably lowered. Whenever the hooks took hold properly, the mechanism of turning the end of vessels large or small, upon itself, was quite easy. In fact, my experiments on dogs have convinced me, that that part of the method will be unobjectionable. I have experimented with very small arteries of dogs, and find that they can be turned inside out as easily and as promptly as the larger ones. I have the assurance of Mr. Stohlman, senior partner of the firm of Geo. Tieman & Co., that the little instrument which seems to be best adapted for the purpose of turning the vessel, can be constructed so as to promptly take hold at any point desirable; and at the present time he is constructing a number of these instruments in proper sizes, to correspond with the different calibers of the arteries which have to be treated.

Judging from the experience that has been gathered by me in regard to this subject, I feel justified in expressing the opinion, that this method of treating arteries is a justifiable proceeding, and that it is practicable in a large number of surgical operations. I also entertain the hope, that whenever the reflection is easily and skilfully performed by the proper instrument, the reflection alone will be sufficient to arrest hemorrhage, and that perhaps only in the largest arteries it may be necessary to add one little peg. The success of the

trials which I have made, seems to me sufficient to justify my bringing this subject to the attention of the profession.

I have taken the liberty to call this method a new method, from the fact that the literature, of thesubject, as far as accessible to me, does not mention a single idea pointing to the principle involved in this method. If it has been my misfortune to overlook the labors of the past and present in this direction, I shall be most happy to give credit where it properly belongs, and renounce all claims of priority. In either case, I beg leave to urge upon the profession a careful investigation and study of the subject.

87 Prospect St., April 15th 1875.